Elemental Mapping of Printed Ink Using the J200 Tandem LA-LIBS Instrument in Combination with the PlasmaQuant MS Elite ICP-MS

Challenge

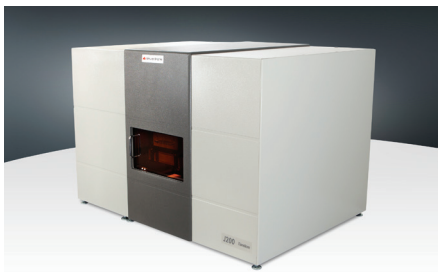
Fast and precise elemental mapping in printed ink within a wide measurement range.

Solution

Simultaneous detection of elements including non-metals using LIBS in combination with LA-ICP-MS.

Introduction

The J200 Tandem LA–LIBS instrument from Applied Spectra, Inc. provides the unique capability of combining the analytical benefits of both LA-ICP-MS (Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry) and LIBS (Laser Induced Breakdown Spectroscopy). Specifically, LIBS provides greater elemental coverage from H – Pu, including elements that are difficult or impossible by conventional ICP-MS instrument such as non-metals (e.g. H, N, O), and halogens (e.g. F).



Applied Spectra J200 Tandem LA-LIBS

When coupled with an Analytik Jena PlasmaQuant MS Elite ICP-MS, it can perform LA-ICP-MS measurements focusing on trace elemental and isotopic ratio compositions. Due to the LIBS option it expands the dynamic range of analysis from sub-ppb levels with LA-ICP-MS, to % levels with LIBS. The ability to determine the elemental distribution in a given sample can be very valuable for manufacturing, failure analysis, and/or quality control in an industrial environment. In general, elemental mapping evaluations take hours to get high-quality, detailed images.

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Therefore, improvement to analysis time results in significant advancements in the efficiency of these types of analysis. Using the J200 Tandem LA-LIBS in combination with the PlasmaQuant MS Elite allows for fast and precise elemental mapping. The data obtained from these experiments (ICP-MS and LIBS) are analyzed and mapped effortlessly using Applied Spectra's Data Analysis Software Package.

Instrumentation

Operating Parameters Analytik Jena PlasmaQuant MS Elite

- Time resolved data acquisition
- High sensitivity optimization
- Peak hopping mode: $^{24}Mg^+$, $^{27}Al^+$, $^{49}Ti^+$, and $^{88}Sr^+$
- Synchronized communication triggering with J200 Tandem LA - LIBS Instrument

Operating Parameters Applied Spectra J200 Tandem LA-LIBS

- Nd:YAG laser (ns)
- Dual LIBS detector for broadband and high-sensitivity mode analysis
- Applied Spectra's Axiom instrument operating software
- Flex sample chamber with helium or argon gas flow
- Sample = printed ink from a business card
- LIBS and LA-ICP-MS data analyzed and converted to images with Applied Spectra Data Analysis Software package

Sample Analysis

The J200 Tandem LA–LIBS instrument in combination with the Analytik Jena PlasmaQuant MS Elite was used to analyze the printed logo from a business card (Fig. 1). The logo area (~ 52.5 mm^2) took ~ 37 minutes to analyze.

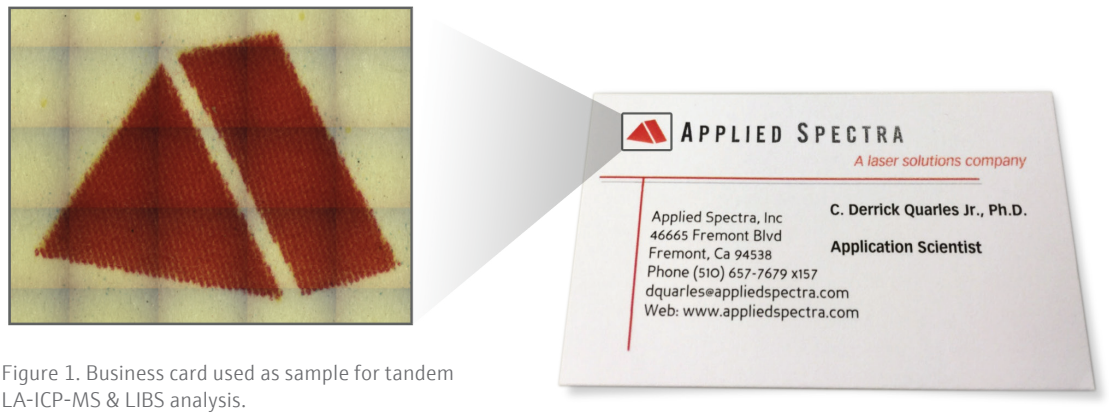

Figure 1. Business card used as sample for tandem LA-ICP-MS & LIBS analysis.

Preliminary analysis suggested that Mg, Al, Ti, and Sr were the best elements to monitor during the LA-ICP-MS part of this experiment. Figure 2 displays the elemental distribution maps for Mg, Al, Ti, and Sr. The signal for Mg was higher in the paper than the red ink. However, the thickness of the ink around the edges appears to be thinner than the center, based on the Mg signal detected around the edges of the sample. The Al response is clearly only from the paper and no Al was detected in the red ink of the logo. Typical elements for coloring such as Ti and Sr show very strong signal from the red ink, but were not detected in the paper. These maps, measured 8.9 mm wide by 6.2 mm high, with 0.15 mm spacing, had 42 lines with 301 shots per line. They were created in ~ 37 minutes, show good resolution, and can provide results in a fast manner, when compared to other techniques for obtaining this type of information.

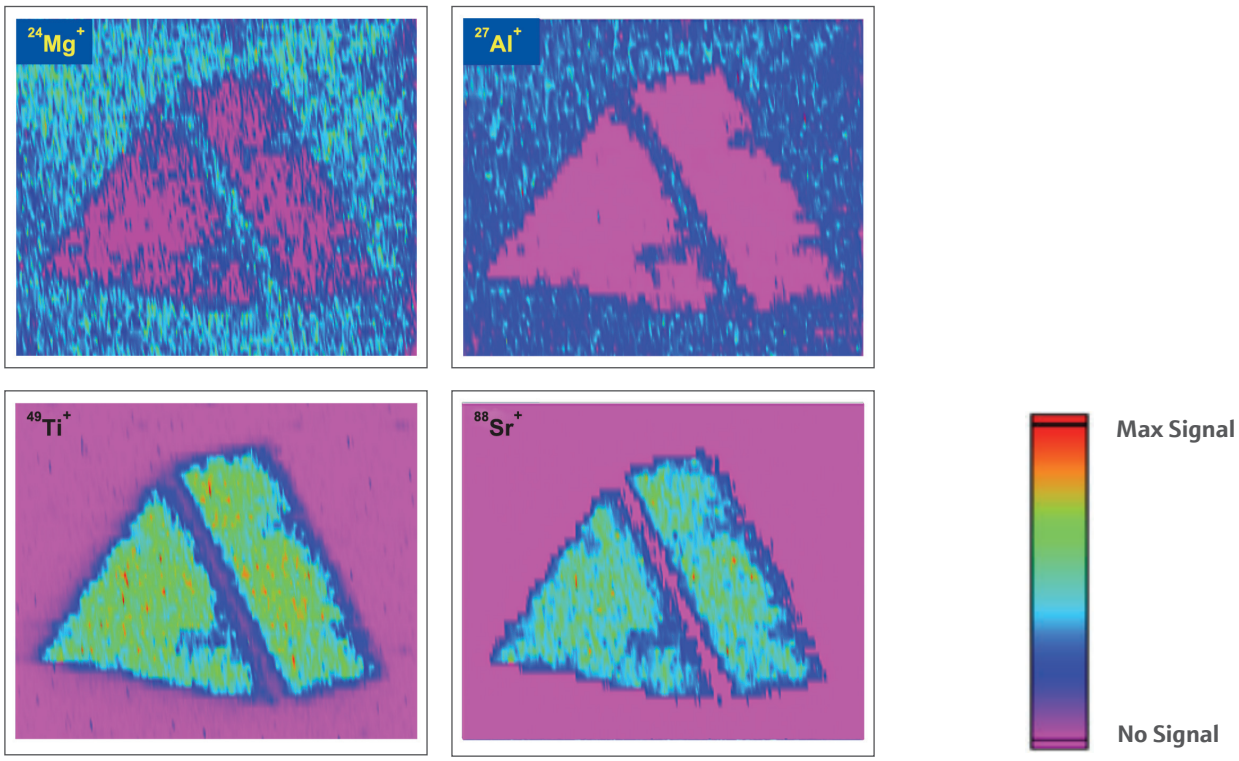

Figure 2. LA-ICP-MS elemental maps based on Mg, Al, Ti, and Sr signals obtained from the Analytik Jena ICP-MS combined with the J200 Tandem instrument.

Complementing the LA-ICP-MS with LIBS provides the ability to detect all elements simultaneously, even elements that are difficult or impossible (e.g. C and H) to detect by ICP-MS. With a broadband detector, the J200 Tandem can capture LIBS spectra from 190 to 1040 nm simultaneously with each laser pulse. Figure 3 displays the elemental maps for C, H, Ti, and Sr by LIBS. The LIBS signal for Ti and Sr support the maps presented in Figure 2. LIBS offers the unique capability of detecting the H signal from the ink.

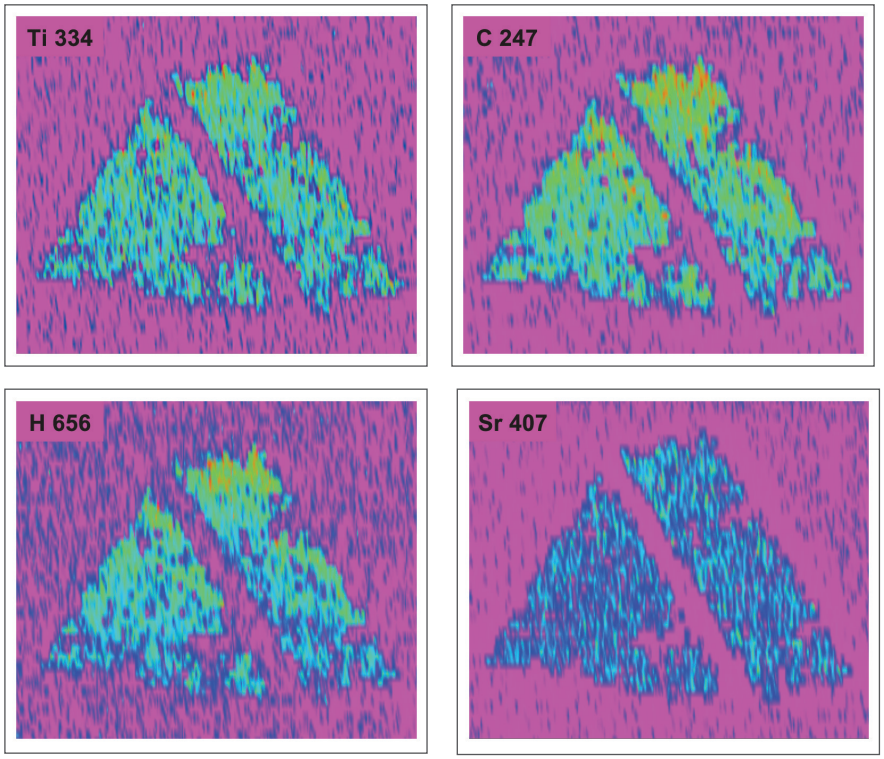

Figure 3. LIBS elemental maps based on C, H, Ti, and Sr signals obtained from the J200 (CCD detector)

The J200 Tandem can integrate both a broadband CCD and scanning-type ICCD detector. Figure 4 shows the Sr response from the more sensitive ICCD detector. The ICCD detector provides increased sensitivity, as compared to the CCD detector, and can scan different spectral regions, depending on the choice of grating, to investigate specific elements with higher detection sensitivity. Regardless of the detector option used for LIBS, the Sr response is not homogenous in the logo (LIBS or LA-ICP-MS maps) that was analyzed. Both LIBS detector configurations gave valuable information about the sample, with regards to this element.

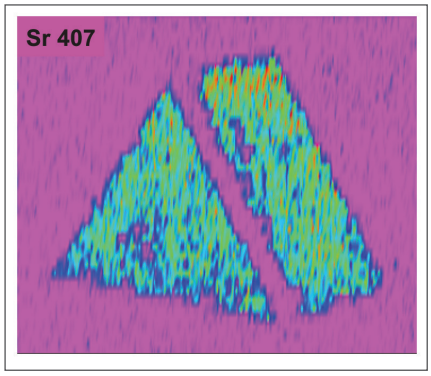

Figure 4. LIBS elemental map based on Sr signal obtained from the J200 (ICCD detector).

Conclusions

Combining LA-ICP-MS and LIBS using the PlasmaQuant MS Elite and J200 Tandem instruments provides a simultaneous solution for elemental mapping of any given sample. The printed logo sample had detectable amounts of Sr, Ti, C, and H. The business card paper had high levels of Mg and Al detected, however these elements were not found in the red ink. This mapping method can be applied to any sample with the same level of success. The Data Analysis package offered by Applied Spectra makes data processing and the creation of elemental maps easy and efficient.

Acknowledgements

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